ALUMINIUM-BASED CASTING ALLOYS WITH GOOD HEAT-CREEP RESISTANCE

Technical field of the invention

This invention relates to aluminium alloys suitable for casting, having good heat-creep resistance, good ductility and intended more specifically for producing motor vehicle engine parts such as, for example, pistons and cylinder heads.

It is known that, for this type of application, the use of aluminium- and silicon-based casting alloys have, in addition to the advantage of a low weight of parts, the benefit of being suitable for casting, which is important for producing cylinder heads or pistons, often having a complex shape.

The good heat conductivity also constitutes another reason for the strong development of these alloys due to the good heat transfer properties that said parts must have.

Currently, the alloys most commonly used are for cylinder heads, A-S7G03 or A-S5U3G and for pistons, A-S12UN or A-S18UNG, these references corresponding respectively to the following designations: AA356, AA319, AA413 and AA392, according to the Aluminum Association standards.

However, due to the increase in power of the engines and, in particular, in the case of turbodiesels, these parts are increasingly being activated thermomechanically, which presents the problem of creep (denting on use of the valve seat support areas) and thermal fatigue (cracking of the intervalve fitting of

the cylinder heads and the piston heads), problems that the traditional alloys cited above cannot resolve.

Given the need to maintain good casting properties, good mechanical properties at room temperature and avoiding additional costs, solutions to these problems have been sought, such as the addition of contents of less than 1 % of elements capable of enhancing the heat properties of the traditional alloys so as to enhance their performance in use.

Prior art

One of the solutions taught by the prior art for improving the heat creep resistance of these alloys consists of adding titanium.

For example, the following can be cited:

- the Japanese patent application published in 1981 under number 56-9351, which describes a heat-resistant aluminium casting alloy containing, by weight, 10.5 to 11.5 % silicon, 3.0 to 4.0 % copper, and 1.0 to 2.5 % magnesium to which 0.25 to 0.40 % titanium is added, said alloy being intended for the production of automobile engine pistons.

- the Japanese patent published in 1982 under number 57-9426, which describes, for the production of pistons, an aluminium alloy containing, by weight, 4 to 14 % silicon, 1 to 5 % copper, 0.2 to 0.8 % magnesium, and capable of also containing 0.5 to 2.5 % nickel or 0.5 to 2.0 % manganese or 0.05 to 0.2 % titanium.

It should also be noted that the use of titanium for refining primary aluminium in hypoeutectic

aluminium-silicon alloys (Si < 13 %) has been known for a long time.

Another solution consists of adding zirconium. Thus:

- the Japanese patent application published in 1979 under number 54-89913, which describes an aluminium alloy having an improved heat resistance and good castability properties, containing, by weight, 1.5 to 5 % silicon, 0.8 to 2 % copper, 0.3 to 1.5 % manganese, 0.3 to 3.5 % magnesium, and 0.01 to 0.3 % iron, and to which either titanium or zirconium is added in an amount of 0.01 to 0.3 %.

A third solution relates to the addition of vanadium. This is described in the Japanese patent published in 1983 under number 83-100654, which teaches the use, for the production of automobile engine parts, of an aluminium alloy containing 8 to 13 % silicon, 2.0 to 5 % copper, and 0.2 to 0.8 % magnesium, to which 0.05 to 0.5 % vanadium has been added to improve its heat resistance.

Stated problem

In the tests conducted to verify the influence of the addition of titanium, zirconium or vanadium, it has been noted that:

- none of these additions made it possible to obtain an increase in creep resistance exceeding 15 % at 300 °C.

- the use of these additions beyond a critical concentration causes the appearance of coarse intermetallic phases ineffective in the improvement of

creep resistance and highly detrimental to the ductility of the alloy and the cracking behaviour on use.

These critical contents are on the order of 0.20 % for titanium, 0.20 % for zirconium and 0.40 % for vanadium.

Description of the invention

It is with the goal of further enhancing this heat creep resistance without adversely affecting the ductility and the cracking behaviour that the applicant has developed aluminium-based casting alloys containing silicon in an amount between 4 and 23 % by weight and at least one element chosen from magnesium, in an amount between 0.1 and 1 % by weight, copper between 0.3 and 4.5 % and nickel between 0.2 and 3 %, as well as the usual impurities, characterised in that, in order to enhance their heat creep resistance without adversely affecting their ductility, said alloys also contain, by weight, 0.1 to 0.2 % titanium, 0.1 to 0.2 % zirconium and 0.2 to 0.4 % vanadium.

Thus, the invention consists of the simultaneously addition of three elements in well-defined proportions.

Indeed, within the minimum values of the ranges indicated, the improvement exists, but is inadequate; however, beyond the maximum values indicated, creep resistance improvements are no longer observed, but instead a reduction in the ductility of the alloy is noted, due to the appearance of coarse phases resulting from the formation of precipitates of coarse intermetallic compounds.

It is also noted that this improvement increases as a function of the content of each of the three elements.

The invention is based on the following surprising observation: given the fact that the elements titanium, zirconium and vanadium are elements with similar physicochemical properties, a person skilled in the art might have expected not to obtain a substantially increase in the heat properties by a simultaneous addition of these three elements with respect to those accessible by adding a single one of these three elements; the idea implicitly accepted in principle being that each of the elements can be substituted for another, as is derived from the Japanese application 54-89913 cited above, in which zirconium is substituted for titanium.

However, it is noted that the simultaneous addition of the three elements in amounts greater than those specified above makes it possible to obtain, all else being equal, a much better creep performance than with the alloys containing only one or two of the three elements, without any notable loss of ductility.

The aluminium alloys used in the invention are preferably chosen from the alloys AA356, AA319, AA413 and AA392 according to the Aluminum Association standards.

Examples of applications

In the examples provided below, the creep resistance indicated is that measured after 100 hours at 300 °C without stress and corresponds to the stress

causing a deformation of 0.1 % (creep by stretching) after 100 test hours.

The ductility indicated is quantified by a stretching test at 250 °C and corresponds to the elongation at rupture in %.

Example 1

An aluminium-based casting alloy of the A-S5U3G type containing less than 100 ppm by weight of each of the elements titanium, zirconium and vanadium and heat treated in state T6 according to the Aluminum Association standards was kept at 300 °C for 100 hours. The measurement of the creep resistance gave a value of 24 MPa and the elongation was 24.0 %.

Example 2

0.13 % titanium by weight was added to an alloy with the composition of example 1, and it was heat treated in the same way as above. The measurement of the creep resistance gave a value of 27 MPa, i.e. an increase of 12.5 %, and the elongation was 19.5 %, corresponding to a relatively small decrease in the value obtained without the addition.

Example 3

0.15 % zirconium by weight was added to an alloy with the composition of example 2, and it was heat treated in the same way as above. A creep resistance value of 29.7 MPa was noted, i.e. another increase by 10 %, and the elongation was 19.0 %, which is

comparable to the value of the preceding example. No presence of coarse phases was noted.

Example 4

0.3 % vanadium by weight was added to an alloy with the composition of example 3, and it was heat treated in the same way as above. The creep resistance value was then 31.8 MPa, i.e. another increase of 7 %, without any observation of coarse phases, and the elongation was maintained at 19 %.

In all, the improvement in heat creep resistance is 32 % and the decrease in elongation is comparable to that of the addition of 0.13 % titanium alone or 0.15 % zirconium alone or 0.3 % vanadium alone.

Similar results were obtained with alloys of the A-S5U3 type, heat-treated for 10 hours at 515 °C.

The invention can be applied in the production of automobile engine cylinder heads and pistons.

CLAIMS

1. Aluminium-based casting alloys containing silicon in an amount between 4 and 23 % by weight and at least one element chosen from magnesium, in an amount between 0.1 and 1 % by weight, copper between 0.3 and 4.5 % and nickel between 0.2 and 3 %, as well as the usual impurities, characterised in that, in order to enhance their heat creep resistance without adversely affecting their ductility, said alloys also contain, by weight, 0.1 to 2.0 % titanium, 0.1 to 0.2 % zirconium and 0.2 to 0.4 % vanadium.

2. Alloys according to claim 1, characterised in that they belong to the group constituted by AA356, AA319, AA413 and AA392, according to the Aluminum Association standards.